4.3 Windstorms

4.3.1 Nature of the Hazard

Windstorms are exceptionally strong winds; they can occur as sharp gusts or as sustained winds. Hurricanes and tornados (also twisters or funnel clouds) are commonly associated with windstorms. However, windstorms can occur without such noticeable visual displays.

When a strong windstorm strikes a community, it leaves behind a distinctive trail. Trees toppled over on buildings and cars, downed power lines crisscrossing the roads, and widespread power outages are a few of the signs that a windstorm has struck. After such an event, it can take communities days, weeks, or longer to return to normal activities. In addition to costly structural damages, windstorms can cause injury or even death.

Historical Windstorm Events

Benton County is subject to severe windstorms. Wind speeds can routinely reach 60 mph. During a five-day windstorm event in January 1972, wind speeds (gusts) up to 150 mph were recorded on Rattlesnake Mountain. In Toppenish (Yakima County), the January 1972 windstorm leveled buildings, tore off roofs, and overturned trailers. The January 1972 windstorm caused an estimated $250,000 in damages (1972 dollars) in Benton County. In a January 1990 windstorm, wind gusts up to 81 mph were recorded. The January 1990 windstorm caused an estimated $3,000,000 in damages. Severe windstorms were also experienced in December 1995 and December 2001, causing damage to roofs, trees, and other property.

There have been few tornados sighted in Benton County since 1958, although a funnel cloud was reported near Prosser in 2003. Adjacent counties have had tornado sightings. However, while there is a potential threat from tornados; they have not been a primary source of damage in the past.

The following recent windstorm events are a sample of the records that are available. There were 43 thunderstorm and high wind events that were reported in Benton County, Washington between 01/01/1950 and 05/31/2003. In addition there were four dust storms, three funnel cloud sightings, and one tornado in 1956.

28 Oct 2003
Southwest winds of 30 to 40 mph with peak gusts of 56 mph at Hanford blew through Benton County, knocking out power, causing multiple-vehicle collisions, blowing down trees, causing fires, and damaging property. About 30 cars and semi-trucks collided on Highway 221 approximately six miles south of Prosser. The collision, at about 3:30 p.m., was attributed to poor visibility due to blowing dust. S.R. 221 remained closed following the collision until almost 8 p.m. In Richland, a tree blew down onto power lines, knocking out power to almost 800 residents. In Kennewick, a power line broke from a pole; sparks from the live line started a small fire. Dust driven by the winds exceeded the densest allowable federal particulate concentration of 150 micrograms per cubic meter as reported in the Tri-City Herald, October 29, 2003. Several Hanford contractors sent employees home early due to the poor air quality.

22 Mar 2003
Strong winds atop Rattlesnake ridge were enough to drag a car off the main road and onto the edge of a bank. The winds continued to pound the side of the vehicle, before rolling the car over onto its top.

05 Mar 2003
High winds were measured by two Hanford Mesonet sites. Peak wind gusts of 68 mph were recorded in an area north of Benton City. Utility crews and law enforcement reported some localized power outages, along with a couple of uprooted road signs.

07 Feb 2002
High wind caused over 800 people to lose power when trees fell on power lines in Pasco and Finley. Two tractor trailers were overturned, one on Interstate 82 and the other on Interstate 182. Fences were blown down the street into neighboring houses, causing damages to roofs. The Tri-Cities Airport Automated Surface Observation Station (ASOS), a weather reporting station operated by the Federal Aviation Administration, reported a wind gust to 60 mph in Pasco, directly across the Columbia River from Kennewick and Finley.

24 Jan 2002
Strong winds caused a tractor trailer to overturn on Highway 240 west of Richland..

01 Dec 2001
High winds brought scattered damage to the Lower Columbia Basin during the afternoon and evening. Widespread wind gusts of over 60 mph were felt over an area including Hanford, Mesa, Kennewick, and Richland. One of the automated wind sensors at Hanford measured a peak wind gust of 72 mph. Near Richland, several road signs were damaged along Interstate 82. Winds also blew part of a roof off of a house in Kennewick. Power was lost to parts of the Tri-Cities metropolitan area during the early evening, while several streets were temporarily closed due to downed trees and power lines.

15 Dec 2000
Strong winds blew throughout the night along the eastern slopes of the Washington Cascades, the Columbia Basin, and the Blue Mountains of Washington. At 10:35 pm, a spotter four miles east of Benton City measured wind gusts as high as 60 mph. Overnight, high winds blew several walls down within a partially completed home in Kennewick. In Richland, several trees were lost and several minor accidents were reported due to winds and slick roads.

15 March 1993
High winds approaching 80 mph damaged a large number of trees throughout the City of Richland. Large amounts of debris were delivered to the landfill soon after the storm. Subsequent tree removal and continuing cleanup efforts generated approximately 600 stumps about six months after the storm. FEMA monies were used to dispose of the stumps.

Characteristics of Windstorms

Prevailing winds in Washington vary with the seasons. In summer, the most common wind directions are from the west or northwest; in winter, they are from the south and east. However, local topography plays a major role in affecting wind direction. Benton County and the surrounding area are famous for receiving strong winds. Some of these strong wind events can become very intense and last for several hours

In the 1950s, the National Weather Service began documenting and classifying strong and severe weather events. These events are categorized by state and counties and put into a book termed Storm Data (available on line at www.ncdc.noaa.gov), which provided the basis for the following summaries of Benton County winds.

A total of 79 (documented) strong wind events have occurred during the period between 1970 to present. Figure 4.3-1 below illustrates the different types of strong wind events as well as the number of times per month they have occurred during the past 33 years.

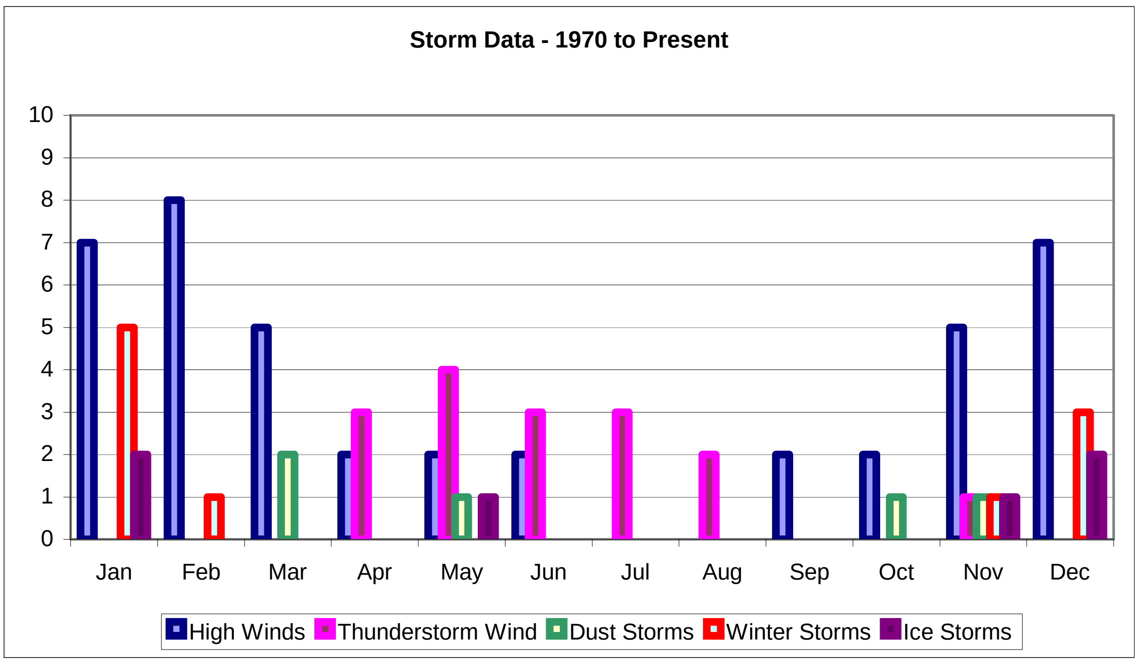

Figure 4.3-1. Number of windstorm occurrences by month in Benton County from 1970 to 2003

The most damaging types of wind events typically last over longer durations and occur over the winter months. The National Weather Service classifies these types of occurrences as "High Wind" events. They are typically associated with a large-scale weather pattern that creates strong low-pressure storm systems off the Pacific Northwest coast. As these strong storms move on shore, pressure gradients create strong surface winds that can last several hours. As the low-pressure system moves inland along the Washington/Canadian border, the passage of the trailing cold front and relatively dense air (more commonly called a Bora) moves over the Cascades and through the canyons and over the foothills of eastern Washington. These local topographic features (e.g. canyons and foothills) can serve to intensify these winds.

The National Weather Service has recorded a total of 42 High Wind events for Benton County over the past 33 years. Wind speeds associated with these 42 events have ranged from as low as 35 mph to as high as 114 mph. These wind speeds were reported at various locations throughout Benton County. The average duration for these High Wind events was 5.8 hours.

Topography plays a large role in the velocity of the wind speeds during these Bora or High Wind events. Figure 4.3-2 illustrates how canyons can funnel strong winds into the western and southern portions of the communities of Kennewick, Richland, and West Richland. The picture below also illustrates the higher terrain on the western side of these communities. Strong westerly cold fronts will flow down these foothills and create the strongest winds on the western side of these cities. Prosser and Benton City are also similarly affected by higher terrain to their south and west..

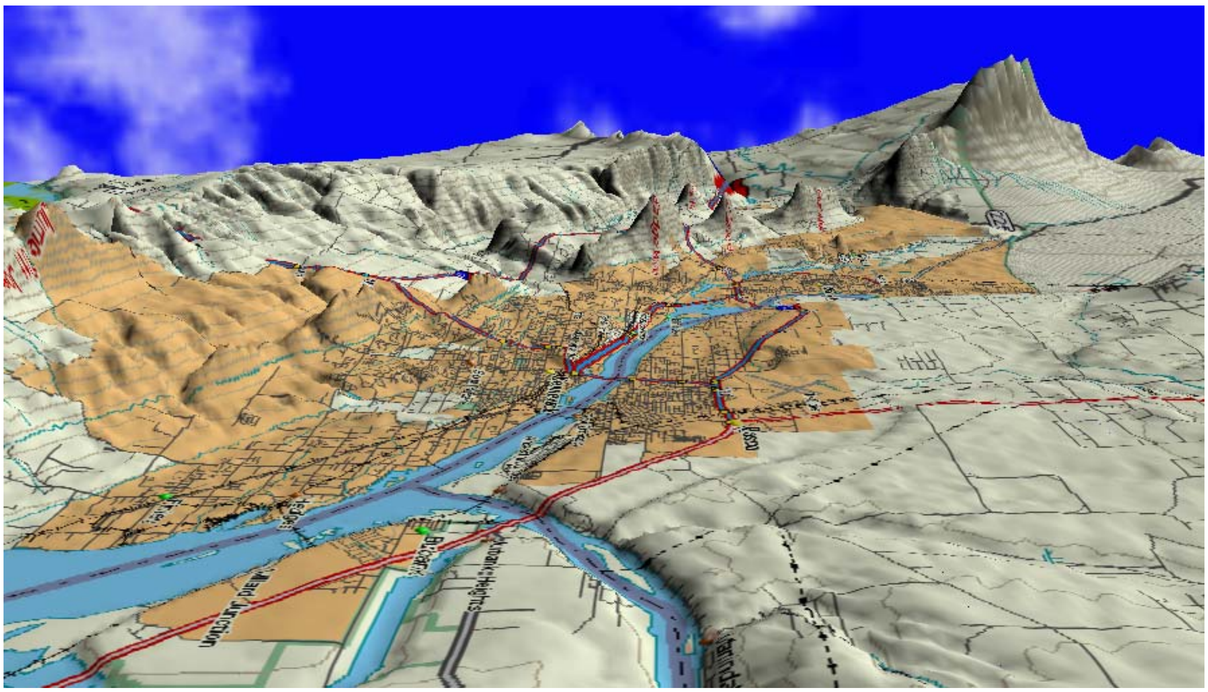

Figure 4.3-2 Topographic view of the Tri-Cities, WA (facing due west)

Strong winds generated by thunderstorms and microbursts are the second most common type of strong winds in Benton County. These storms have produced recorded sustained winds of 64 mph with wind gusts as high as 67 mph during the months of April, May, June, July, and August. Thunderstorm and microburst winds are relatively short-lived, but can still cause significant localized damage. This type of wind event has been reported to occur 16 times over the last 33 years.

Other events such as ice storms and dust storms create strong winds as well. However, they occur on such an infrequent basis that they were not considered to pose a significant risk, and were not specifically addressed as a separate issue.

Recorded average two-minute wind speed and directional data was gathered from the Yakima Air Terminal for the time period of 1996 to present. This location was chosen due to its length of consistent data as well as its proximity to Benton County. The two-minute wind average was used due to the fact that the majority of strong wind events that affect the region are from long duration sustained wind events. The results of this data are indicated in the graphs depicted below. For reference in reading the graphs: east is 90 degrees; south is 180 degrees; west is 270 degrees; and north is 0/365 degrees. Wind speed (as shown in the graphs) is typically measured in knots: 1.0 knot is equivalent to 1.152 mph.

The first graph indicated as Figure 4.3-3 illustrates that the strongest average sustained winds originate out of the south-southwest. However, Figure 4.3-4 indicates that the majority of the wind occurrences originate out of the west-northwest. The final graph, Figure 4.3-5, illustrates that the majority of peak gusts originate from a south-southwest to west-northwest direction. Therefore, the strongest sustained winds in Benton County are most likely to be out of the south-southwest to the west-northwest.

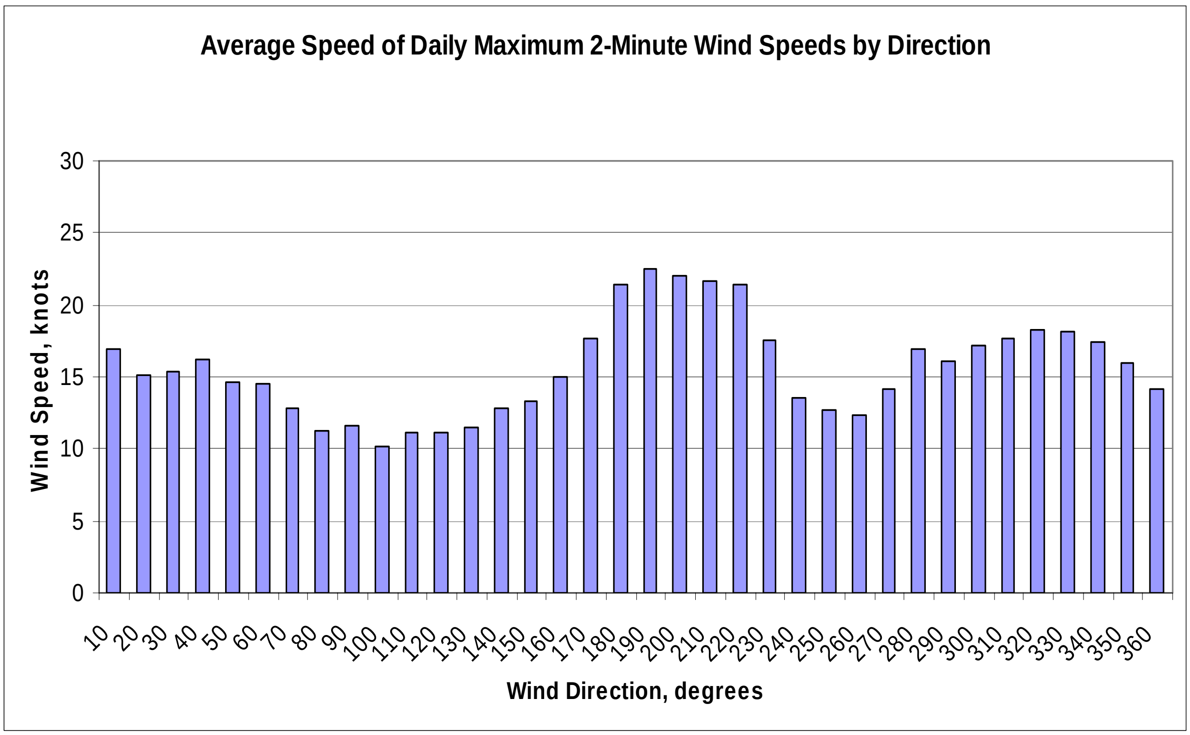

Figure 4.3-3. Graph of wind direction and average wind speed

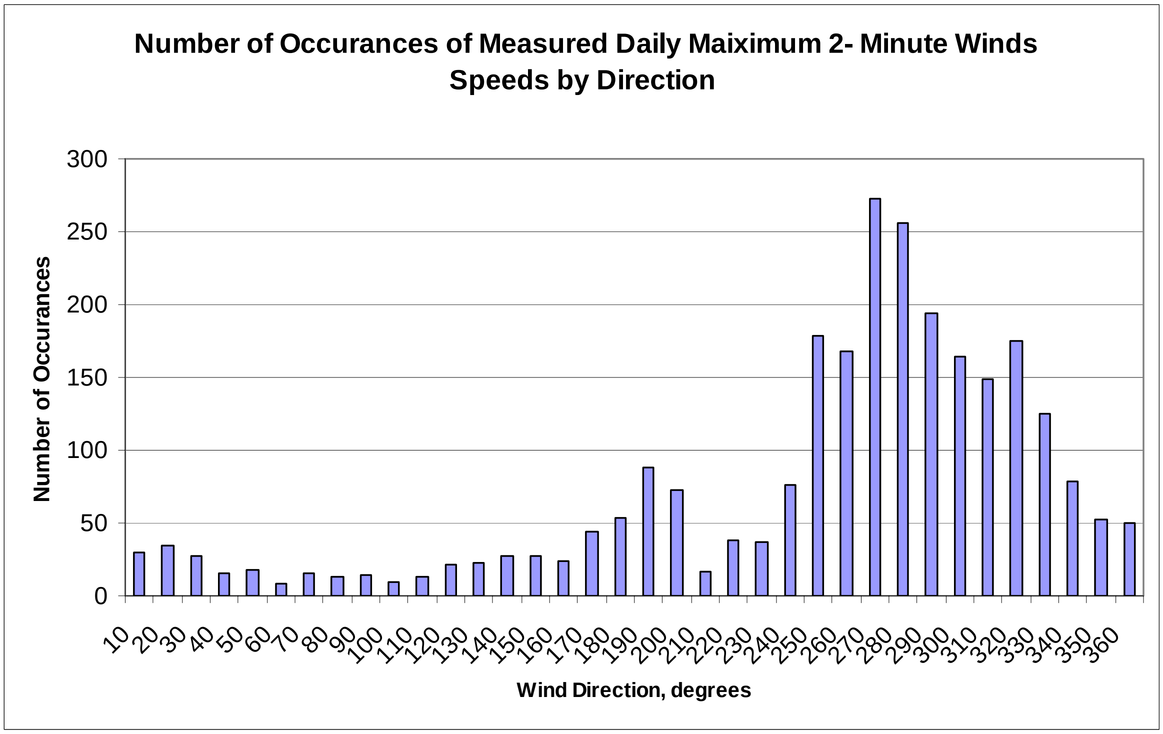

Figure 4.3-4. Wind direction and number of occurrences

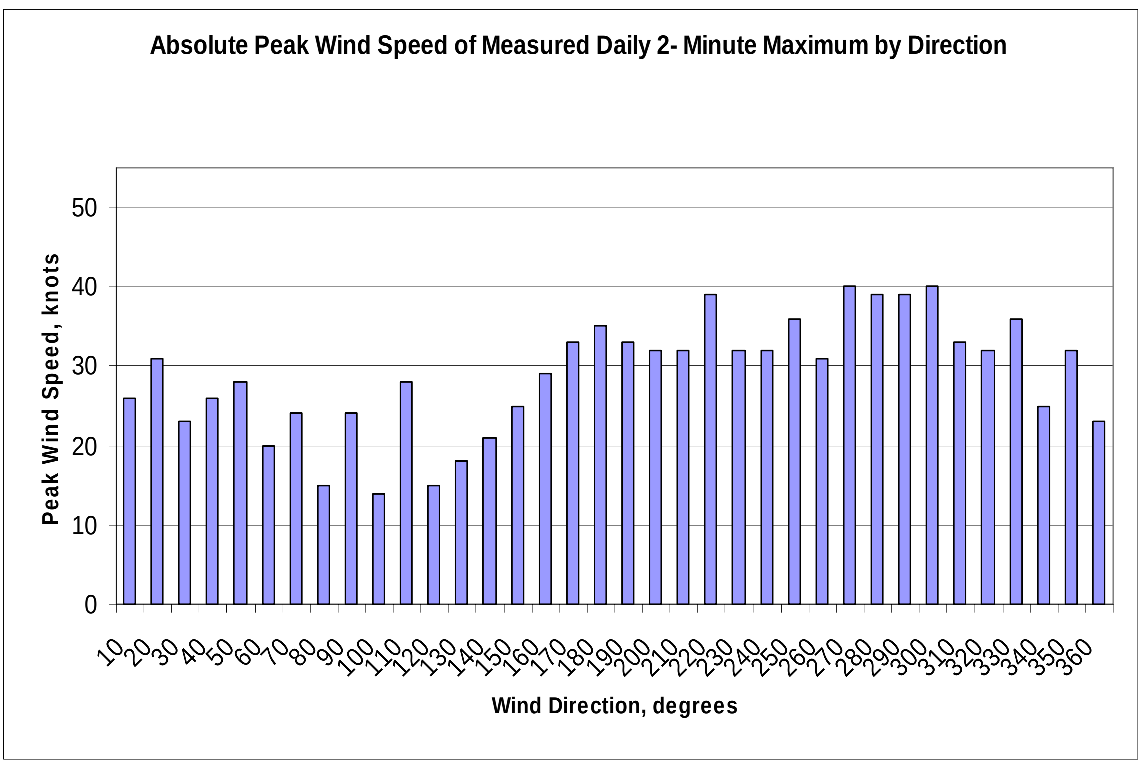

Figure 4.3-5. Wind direction and peak wind speeds

There is a good correlation between the measured storm events in the Storm Data archives for the average wind speeds and the peak wind speeds (Figure 4.3-6). This data was taken from 25 of the high wind events for Benton County shown in Table 4.3-1. Analysis of these long duration high wind events shows that, on average, the peak wind speed is roughly 15 percent greater than the average wind speed for that particular event. This knowledge will help forecasters anticipate peak winds when the average wind speeds are forecasted.

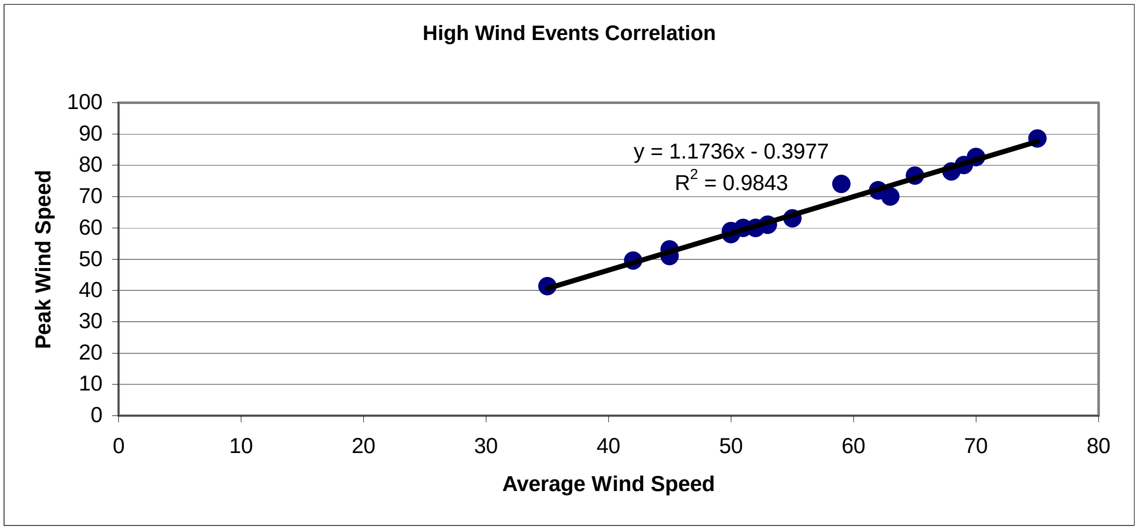

Figure 4.3-6. Correlation between Average Wind Speed and Peak Wind Speed

Chinook Winds

Another category of wind affecting Benton County are “Chinook” winds. Chinook is a native-American word meaning “snow eater.” The Chinook wind is a warm, dry wind from the east that often leads to the rapid disappearance of snow, and can gust up to 100 miles per hour. The gusts are caused by rapid atmospheric pressure changes. Studies have shown that these changes can result in physiological and psychological reactions in humans such as headaches and increased irritability. Chinook winds are often associated with contributing to winter flooding along the Yakima River.

Tornadoes

Tornadoes are the most concentrated and violent storms produced by the earth’s atmosphere. They are created by a vortex of rotating winds and strong vertical motion, which possess remarkable strength and cause widespread damage. Wind speeds in excess of 300 mph have been observed within tornadoes, and it is suspected that some tornado winds exceed 400 mph. The low pressure at the center of a tornado can destroy buildings and other structures it passes over. Tornadoes are most common in the Midwest, and are more infrequent and generally small west of the Rockies. Washington is generally considered to be a low-risk state for tornadoes. Nonetheless, Washington and other western states have experienced tornadoes on occasion, many of which have produced significant damage and occasionally injury or death. Washington’s tornadoes can be formed in association with large Pacific storms arriving from the west. Most of them, however, are caused by intense local thunderstorms. These storms also produce lightning, hail, and heavy rain, and are more common during the warm season from April to October.

Table 4.3-1 High Wind Events (Storm Data)

Date of Event	Average Wind Speed (knots)	Peak Wind Speed (knots)
1/8/1975	63	70
2/19/1975	50	59
3/24/1976	65	77
12/9/1987	75	89
11/23/1990	70	83
11/3/1993	70	83
6/30/1997	50	59
10/30/1997	62	72
12/27/1998	50	58
1/4/1999	51	60
2/2/1999	68	78
2/6/1999	45	53
2/18/1999	45	51
9/25/1999	59	74
12/15/1999	50	58
11/4/2000	53	61
12/4/2000	52	60
4/17/2001	69	80
4/30/2001	42	50
10/23/2001	53	61
12/1/2001	62	72
1/12/2002	50	58
2/7/2002	52	60
5/2/2002	35	41
12/27/2002	55	63

Effects of Windstorms

Windstorms have the ability to cause damage over 100 miles from the center of storm activity. Isolated wind phenomena in the mountainous regions have more localized effects. Winds impacting walls, doors, windows, and roofs, may cause structural components to fail. Wind pressure can create a direct and frontal assault on a structure, pushing walls, doors, and windows inward. Conversely, passing currents can create lift and suction forces that act to pull building components and surfaces outward. The effects of winds are magnified in the upper levels of multi-story structures. As positive and negative forces impact the building's protective envelope (doors, windows, and walls), the result can be roof or building component failures and considerable structural damage.

In the U.S., the Beaufort Scale is commonly used to categorize the effects of wind speed (Table 4.3-1)

Table 4.3-1. The Effect of Wind Speed
Source: Merriam-Webster Dictionary
www.m-w.com

BEAUFORT NUMBER	NAME	WIND SPEED		DESCRIPTION
		MPH	KPH	
0	calm	<1	<1	calm; smokes rises vertically
1	light air	1-3	1-5	direction of wind shown by smoke but not by wind vanes
2	light breeze	4-7	6-11	wind felt on face; leaves rustle; wind vane moves
3	gentle breeze	8-12	12-19	leaves and small twigs in constant motion; wind extends light flag
4	moderate breeze	13-18	20-28	wind raises dust and loose paper; small branches move
5	fresh breeze	19-24	29-38	small-leaved trees begin to sway; crested wavelets form on inland waters
6	strong breeze	25-31	39-49	large branches move; overhead wires whistle; umbrellas difficult to control
7	moderate gale *or* near gale	32-38	50-61	whole trees sway; walking against wind is difficult
8	fresh gale *or* gale	39-46	62-74	twigs break off trees; moving cars veer
9	strong gale	47-54	75-88	slight structural damage occurs; shingles may blow away
10	whole gale *or* storm	55-63	89-102	trees uprooted; considerable structural damage occurs
11	storm *or* violent storm	64-72	103-117	widespread damage occurs
12	hurricane*	>72	>117	widespread damage occurs

*The U.S. uses 74 statute mph as the speed criterion for a hurricane.

Debris carried along by extreme winds can directly contribute to loss of life and indirectly to the failure of protective building envelopes, siding, or walls of buildings. When severe windstorms strike a community, downed trees, power lines, and damaged property can be major hindrances to emergency response and disaster recovery.

Storm winds can damage buildings, power lines, and other property and infrastructure due to falling trees and branches. During wet winters, saturated soils cause trees to become less stable and more vulnerable to uprooting from high winds.

Windstorms can result in collapsed or damaged buildings, damaged or blocked roads and bridges, damaged traffic signals, streetlights, and parks, among others. Roads blocked by fallen trees during a windstorm may have severe consequences to people who need access to emergency services. Emergency response operations can be complicated when roads are blocked or when power supplies are interrupted. Industry and commerce can suffer losses from interruptions in electric service and from extended road closures. They can also sustain direct losses to buildings, personnel, and other vital equipment. There are direct consequences to the local economy resulting from windstorms related to both physical damages and interrupted services.

Windstorms can cause flying debris and downed utility lines. For example, tree limbs breaking in winds of only 45 mph can be thrown over 75 feet. As such, overhead power lines can be damaged even in relatively minor windstorm events. Utility lines brought down by summer thunderstorms have also been known to cause fires, which start in dry roadside vegetation. Falling trees can bring electric power lines down to the pavement, creating the possibility of lethal electric shock. Rising population growth and new infrastructure in the County creates a higher probability for damage to occur from windstorms as more life and property are exposed to risk.

Based on the above potential windstorm effects and a review of historical events, the following areas are likely to be more vulnerable to the effects of high winds:

- Areas with large trees
- Areas dependent upon aboveground power distribution systems
- Areas with older homes or other structures
- Areas with large open agricultural fields or rangeland
- Areas along ridge tops
- Areas where canyons or foothills channel the prevailing winds.

4.3.2 Windstorm Hazard Assessment

Likelihood of Occurrence

A windstorm is generally a short duration event involving straight-line winds and/or gusts in excess of 50 mph. As shown by the historic events and wind data for the County, windstorms can and do affect all areas of the County. It was therefore concluded that there is a **high** likelihood of a major windstorm occurring within the five year planning cycle.

Exposure Assessment

The lower wind speeds typical in the lower valleys are still frequently high enough to knock down trees and power lines, and cause other property damage. Sections of the County with higher elevations (e.g. exposed ridge tops) experience much higher winds under more varied conditions. Local topography, such as canyons, can also serve to channel winds. The southern and western edges of Benton City, Kennewick, Prosser, Richland, and West Richland, as well as those portions of Benton County which abut the foothills on the north and east slopes, are likely to experience increased winds due to the funneling effect of southwesterly winds coming off the adjacent foothills. Figure 4.3-7 (at the rear of this chapter) clearly shows the local topography that accentuates the local wind conditions for these areas.

All areas of the County are exposed to potentially severe windstorms. Although severe wind gusts may occur in localized areas, most windstorms affect the entire County. The southern and western edges of Benton City, Kennewick, Prosser, Richland, and West Richland, as well as those portions of Benton County which abut the foothills on the north and east slopes have an increased potential exposure to severe wind gusts.

Vulnerability Assessment

Given the determination that all of Benton County is exposed to windstorms, the vulnerability assessment focused on identifying those areas where vulnerability is considered likely to be higher.

Areas with large numbers of large trees include the cities, and in particular their older neighborhoods. Some of the irrigated agricultural areas maintain shelterbelts. Most of the remainder of the County lacks any significant trees. Clusters of large trees occur in all of the cities, as well as the communities of Finley, Paterson, and Plymouth.

Local power distribution systems relying on aboveground poles and wires typically occur in the older neighborhoods within the cities and urban areas and in the less developed areas of Benton County. More recent housing developments and subdivisions typically have underground utilities.

Benton County's population is housed in a total of 55,963 housing units. Approximately 32.6 percent of the housing units were built since 1980, 32.3 percent were built from 1970 to 1979, 9.1 percent were built from 1960 to 1969, and 23.2 percent were built from 1940 to 1959. The remaining 2.8 percent of the housing units were built in 1939 or earlier. Older homes and structures are considered more vulnerable to damage from wind. Clusters of older homes occur in all of the cities, as well as the communities of Finley, Paterson, and Plymouth.

Areas with large open agricultural fields or rangeland known to be susceptible to windstorms (e.g., travel disruption and/or road closures due to blowing dust) include:

- State Route 221 from Prosser to Paterson
- State Route 395 south of Kennewick
- I-82 south of Kennewick.

Areas along ridge tops that are experiencing residential development include the ridges of the Horse Heaven Hills facing north towards Kennewick, West Richland, Benton City, and Prosser (see Figure 4.3-7 at the end of this chapter). However, most of the residential development is recent, and the homes are built to modern building codes, limiting their vulnerability to direct wind damage.

Areas likely to experience increased winds due to the funneling effect of southwesterly winds coming off the adjacent foothills include the southern and western edges of Benton City, Kennewick, Prosser, Richland, and West Richland, as well as those portions of Benton County which abut the foothills on the north and east slopes.

Based on the high likelihood of exposure and several factors contributing to high vulnerability to wind damage, there is a **high risk** associated with windstorms in the cities of Benton City, Kennewick, Prosser, Richland, and West Richland and in their urban growth areas. In addition, the communities of Finley, Paterson, and Plymouth have a **high risk** associated with windstorms.

The remainder of the County has a **medium risk** associated with windstorms.

4.3.3 Community Windstorm Issues

Current Conditions

The Benton County Comprehensive Emergency Management Plan cites public education as a key requirement, concluding that "*Public education should be provided to instruct on personal preparedness and what actions should be taken during a severe storm. Emphasis should be placed on the less frequent storms, such as tornados, since the public may not expect them to occur in this area and would not be familiar with their characteristics or the actions to take.*"

Ongoing Mitigation Activities

One of the common problems associated with windstorms is power outage. High winds commonly occur during storms, and can cause trees to bend, sag, or fail (tree limbs or entire trees), coming into contact with nearby distribution power lines. Fallen trees can cause short-circuiting and conductor overloading. Wind-induced damage to the power system causes power outages to customers, incurs cost to make repairs, and in some cases can lead to ignitions that start wildfires. The basic strategy adopted by power companies to avoid wind-induced damage is to maintain adequate separation between their transmission circuits and trees. This is done with tree height limitations and ongoing tree trimming along utility rights of way.

All of the municipalities of Benton County recognize the value of the trees in their communities. Several of the municipalities of Benton County have ongoing tree management programs to maintain the health and condition of trees on public lands and rights of way. These programs provide for removal of damaged or hazardous trees, tree planting, and other maintenance. A common concern for the municipalities is the lack of available funding to develop and maintain more proactive tree management programs.

4.3.4 Windstorm Mitigation Strategy

The following are potential measures to mitigate the hazard posed by windstorms. The list is not definitive – there may be other potential mitigation actions. The potential mitigation measures listed below are not recommended action items for the municipalities of Benton County. Rather, they are included here as examples of the types of mitigation measures other cities and counties have used or considered for similar hazards. The potential mitigation measures have been categorized by the type of mitigation response they represent. Although there are many precautions that can be taken to limit the damage caused by windstorms, it is not feasible to hope to eliminate a naturally occurring hazard, nor to control exposure to such a wide-reaching hazard. Therefore, mitigation response must focus on limiting the vulnerability of people and property to the hazard. Types of mitigation response typically include:

Limiting Exposure

- Removing existing development within the area of hazard.
- Restricting future development within the area of hazard.

Limiting Vulnerability

- Providing structural defenses against the impacts of the hazard.
- Providing nonstructural defenses against the impacts of the hazard.
- Providing hazard mitigation education to affected communities and the general public.
- Ensuring that plans, procedures, facilities, equipment, and trained personnel are available to provide for adequate hazard response and recovery.

Removing existing development within the area of hazard

The area of exposure to windstorms in Benton County is considered to be the entire County, therefore, there are no feasible mitigation measures available to remove development from exposure to the hazard.

Restricting Future Development Within the Area of Hazard

1. Restricting development within specific areas of high risk (e.g., ridge tops) through available land use planning and zoning requirements.

Providing Structural Defenses Against the Impacts of the Hazard

2. Encourage development and enforcement of wind resistant building and construction codes.

3. Roof retrofitting
    a. Redesign/reconstruction for less wind resistance
    b. Stronger roof covering
    c. Strengthen sheathing
    d. Install hurricane clips/straps
    e. Reduce length of unsupported roof spans
    f. Other roof strengthening techniques

4. Wall opening retrofitting
    a. Redesign/reconstruct smaller wall openings
    b. Install permanent storm shutters on windows and doors
    c. Make temporary storm shutters and install placement fixtures
    d. Install laminated glass in windows/doors
    e. Install bracing for larger doors, e.g., garage doors

5. “Hardening” of utility services to facility or system component

6. Replace/bury above-grade utility services, e.g., power, telephone

7. Strengthen aboveground utility poles/conductor fixtures

8. Install “safe rooms” in facilities subject to high-wind hazards.

9. Control of structure’s external features
   - Removal of unnecessary/unused outbuildings, sheds, decks, etc.
   - Install tie-downs for portable outbuildings, sheds, etc.
   - Strengthen/brace/anchor external features, e.g., decks, etc.
   - Install removable external features, e.g., awnings, decks, etc.
   - Remove/trim trees/limbs in proximity to structure

Providing Nonstructural Defenses Against the Impacts of the Hazard

10. Develop and implement programs to keep trees from threatening lives, property, and public infrastructure during windstorm events. Ideas for implementation include:
    a. Partner with responsible agencies and organizations to design and disseminate education information to property owners to reduce risk from tree failure to life, property, and utility systems;
    b. Develop partnerships between utility providers and City and local public works agencies to document known hazard areas; and
    c. Identify potentially hazardous trees in urban areas.

11. Support/encourage electrical utilities to use underground construction methods where possible to reduce power outages from windstorms.

12. Develop/apply criteria to future building, siting, landscaping, etc. for wind protection.

Providing Hazard Mitigation Education to Affected Communities and the General Public.

13. Map and publicize locations around the County that have the highest incidence of extreme windstorms. Ideas for implementation include:
    a. Identify a responsible agency for central collection and reporting of storm data. Data collected should include:
       - Windstorm data (sustained speeds, gusts, storm durations) for localities throughout the County;
       - Maps of the locations within the County, which are most vulnerable to high winds; and
       - Injury and property damage estimates, including locations.
    b. Identify a responsible agency to collect and transfer data to the National Climate Data Center, Office of the Washington State Climatologist, FEMA, or other agencies concerned with the incidence of storms, to help establish and maintain baseline and historic records of storm events; and
    c. Identify public infrastructure and facilities subject to damage or closure during windstorm events.

14. Increase public awareness of windstorm mitigation activities. Ideas for implementation include:
    a. Develop public information programs for protecting life, property, and the environment from windstorm events; and

b. Distribute educational materials to residents and public and private sector organizations regarding preparedness for no power situations.

15. Develop/implement program to promote home retrofitting for wind impact

Ensuring that Plans, Procedures, Facilities, Equipment, and Trained Personnel are Available to Provide for Adequate Hazard Response and Recovery

16. Develop coordinated management strategies for clearing roads of fallen trees, and clearing debris from public and private property.

17. Purchase and install a severe weather/high wind notification system.

18. Install or provide high wind warning equipment (e.g., weather radios)

4.3.5 Windstorm Resource Directory

State Resources

Office of the Washington State Climatologist
The Washington State Climatologist collects, manages, and maintains Washington weather and climate data. The State Climatologist provides weather and climate information to those within and outside the state of Washington and educates the citizens of Washington on current and emerging climate issues. The State Climatologist also performs independent research related to weather and climate issues.
Contact: Washington State Climatologist
Mark Albright, Department of Atmospheric Sciences
Box 351640, University of Washington, Seattle, WA 98195
Phone: (206) 543-0448
Website: http://www.climate.washington.edu
Email: climate@atmos.washington.edu, or marka@atmos.washington.edu

Federal Resources

National Weather Service, Pendleton Weather Forecast Office
The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters, and ocean areas for the protection of life and property and the enhancement of the national economy. NWS data and products, such as Storm Data, form a national information database and infrastructure, which can be used by other governmental agencies, the private sector, the public, and the global community.
Contact: National Weather Service
Address: 2001 NW 50th Drive, Pendleton, OR 97801
Phone: ((541) 276-7832
Website: http://www.wrh.noaa.gov/pendleton/index.shtml

National Oceanic and Atmospheric Administration (NOAA)
NOAA's historical role has been to predict environmental changes, protect life and property, provide decision makers with reliable scientific information, and foster global environmental stewardship.
Contact: National Oceanic and Atmospheric Administration
Address: 14th Street & Constitution Avenue, NW, Room 6013,
Washington, DC 20230
Phone: (202) 482-6090
Fax: (202) 482-3154
Website: http://www.noaa.gov
Email: answers@noaa.gov

Additional Resources

American Association for Wind Engineering
The American Association for Wind Engineering (AAWE) was originally established as the Wind Engineering Research Council in 1966 to promote and disseminate technical information in the research community. In 1983 the name was changed to American Association for Wind Engineering and incorporated as a nonprofit professional organization. The multi-disciplinary field of wind engineering considers problems related to wind and associated water loads and penetrations for buildings and structures, societal impact of winds, hurricane and tornado risk assessment, cost-benefit analysis, codes and standards, dispersion of urban and industrial pollution, wind energy and urban aerodynamics.

Contact: AAWE
Website: http://www.aawe.org

Wind Hazard Reduction Coalition
The goal of the Wind Hazard Reduction Coalition is to support the creation of a National Wind Hazard Reduction Program (NWHRP) that would focus reducing loss of life and property damage significantly. An effective National Wind Hazard Reduction Program would address:

- Better design and construction methods and practices;
- Better emergency response;
- Use of modern technology for early-warning systems;
- Building codes enforcement; and
- Public education and involvement programs.

Contact: Wind Hazard Reduction Coalition
Email: govwash@asce.org
Website: http://www.windhazards.org

Natural Hazards Center at the University of Colorado, Boulder
The Natural Hazards Center, located at the University of Colorado, Boulder, Colorado, is a national and international clearinghouse for information on natural hazards and human adjustments to hazards and disasters. The Natural Hazards Center carries out its mission in four principal areas: information dissemination, an annual workshop, research, and library services. The center's prime goal is to increase communication among hazard/disaster researchers and

those individuals, agencies, and organizations that are actively working to reduce disaster damage and suffering. The Natural Hazards Center has a variety of resources available on the Internet.

Contact: Natural Hazards Center
Address: University of Colorado, 482 UCB, Boulder, CO 80309-0482
Phone: (303) 492-6818
Email: hazctr@colorado.edu
Website: http://www.colorado.edu/hazards/

Public Assistance Debris Management Guide, Federal Emergency Management Agency (July 2000). The Debris Management Guide was developed to assist local officials in planning, mobilizing, organizing, and controlling large-scale debris clearance, removal, and disposal operations. Debris management is generally associated with post-disaster recovery. While it should be compliant with local and City emergency operations plans, developing strategies to ensure strong debris management is a way to integrate debris management within mitigation activities. The *Public Assistance Debris Management Guide* is available in hard copy or on the FEMA website.

Contact: FEMA Distribution Center
Address: 130 228th Street, SW, Bothell, WA 98021-9796
Phone: (800) 480-2520
Fax: (425) 487-4622
Website: http://www.fema.gov/r-n-r/pa/dmgtoc.htm